北大低温研・研究集会

干渉計解析の概要

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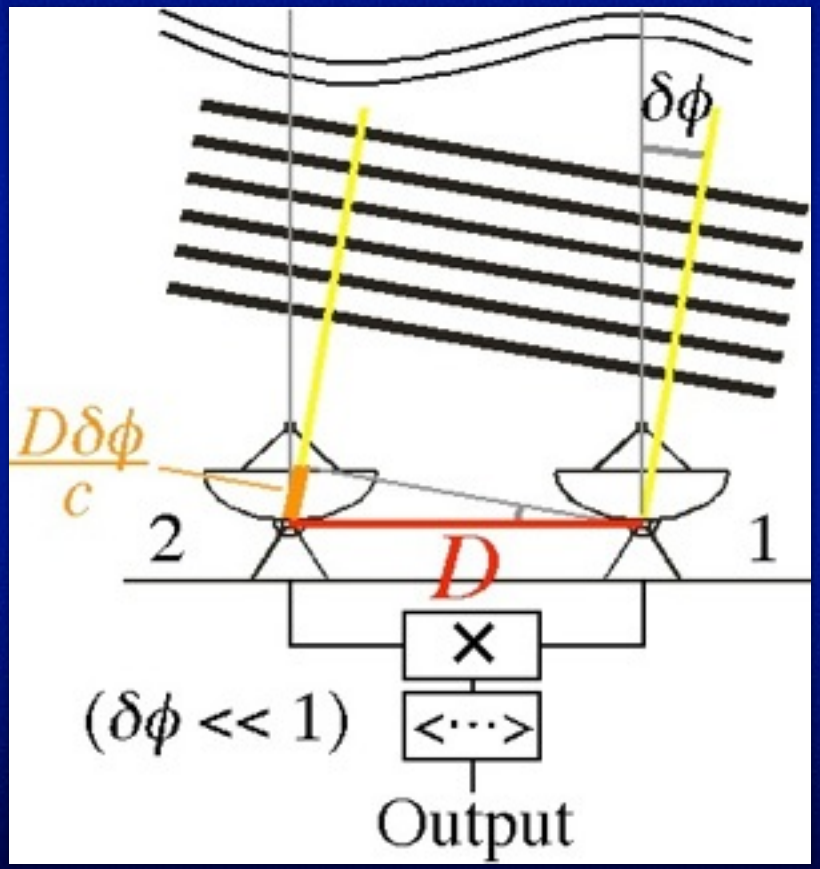
Interferometer in radio (1D): Each antenna obtains "*E*-field" information

Cross correlation for $\delta\phi$ direction

$$|E(\delta\phi)|^2 \exp\left(+i2\pi\frac{D}{\lambda}\delta\phi\right)$$

when the delay is adjusted to the zenith ...



Integrating all the directions

$$V(D) = \int T(\delta\phi) \exp\left(+i2\pi\frac{D}{\lambda}\delta\phi\right) d(\delta\phi)$$

***V*(*D*) is a Fourier component of *T*($\delta\phi$)**

→Image can be reconstructed by data from many baselines

Visibility and Brightness in 2D

Definition of "uv vector" for a projected baseline

$$\vec{D} = (D_u, D_v) \equiv \lambda(u, v)$$

(u, v)は地面，(x, y)は天球。$u \parallel x$は東西，$v \parallel y$は南北

Fourier Transform between Visibility and Sky Brightness

$$V(u,v) = \iint T(x,y) e^{+i2\pi(ux+vy)}\, dxdy$$

$$T(x,y) = \iint V(u,v) e^{-i2\pi(ux+vy)}\, dudv$$

In reality, (1) antenna power pattern and (2) uv-sampling also affect the obtained data …

$$(1)\quad \underbrace{V(u,v)}_{\text{(得られるビジビリティ)}} \Leftrightarrow \underbrace{P(x,y)}_{\text{(パワーパターン)}}\underbrace{T(x,y)}_{\text{(真の輝度分布)}}$$

※パワーパターンは測定可能な量

$$(2)\quad \underbrace{P(x,y)T_{\rm dirty}(x,y)}_{\text{(直接出るマップ= Dirty Map)}}$$

$$= \iint \underbrace{[S(u,v)}_{\text{(標本関数 or 重み関数)}} V(u,v)]\, e^{-i2\pi(ux+vy)}\, dudv$$

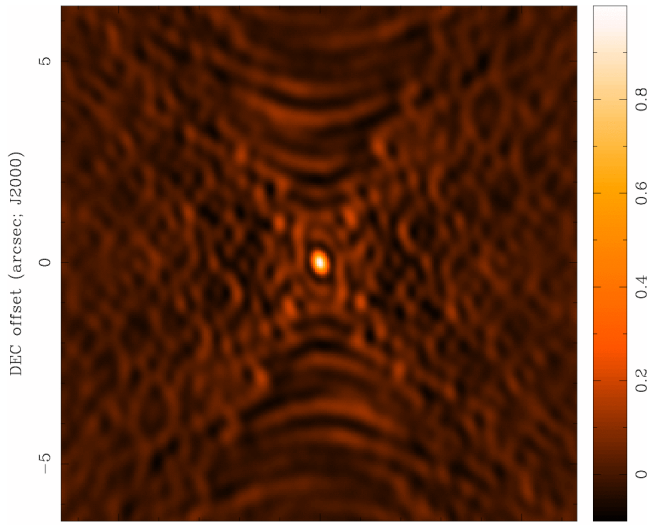
$$= \underbrace{B(x,y)}_{\text{(Dirty Beam)}} * [\underbrace{P(x,y)T(x,y)}_{\text{(求めたい輝度分布)}}]$$

$$\text{where } S(u,v) \Leftrightarrow B(x,y)$$

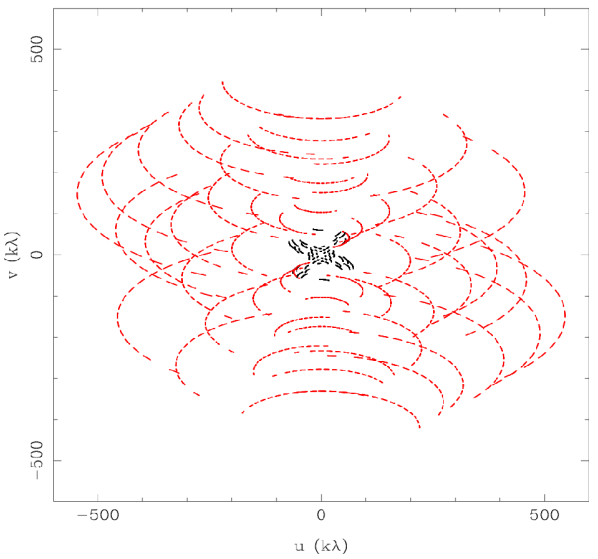
※関数積のフーリエ変換 = 各関数のフーリエ変換の畳み込み

Visibility vs. Image (from NAASC Memo #104)

$B(x,y)$



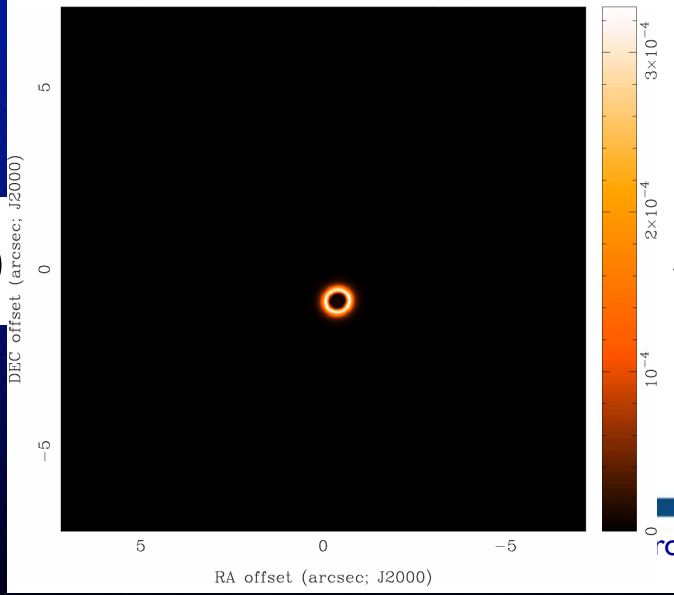
$\rightleftharpoons$



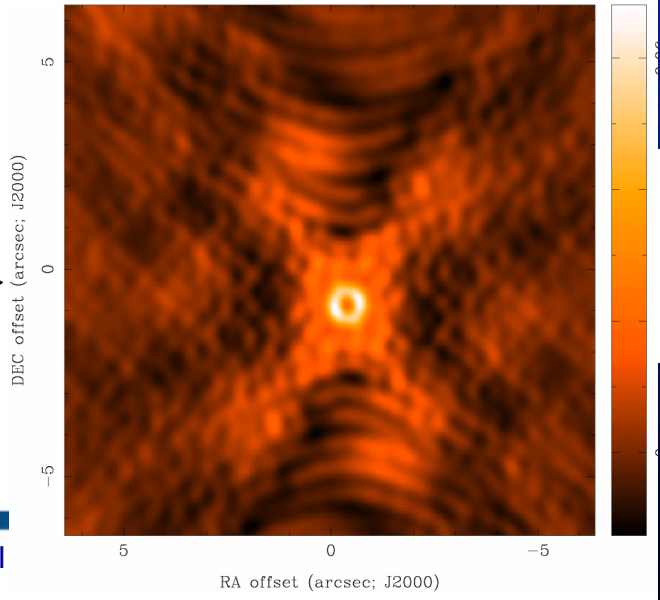
$S(u,v)$

$\otimes$ convolution

$T(x,y)$

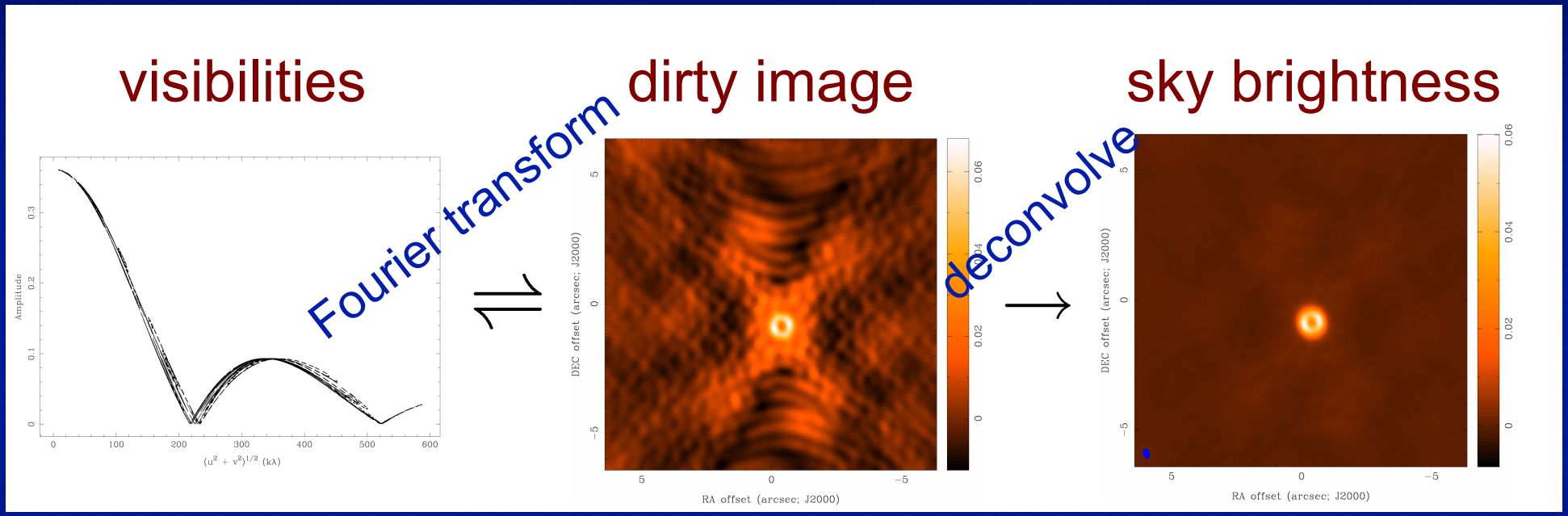


$\rightarrow$



Dirty Image

Visibility →Dirty Image→Deconvolved Image (from NAASC Memo #104)



Deconvolution Method

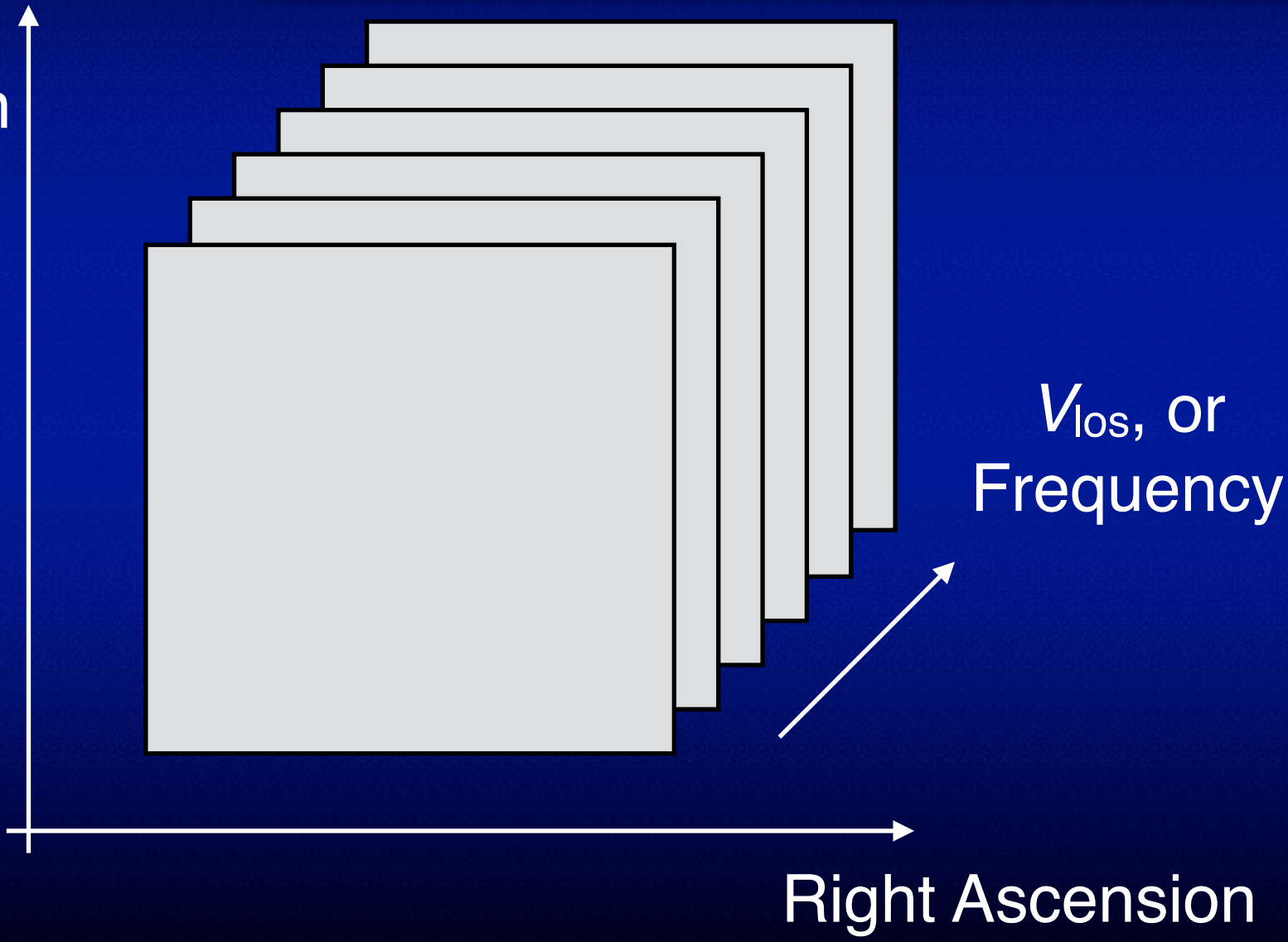
CLEAN

MEM

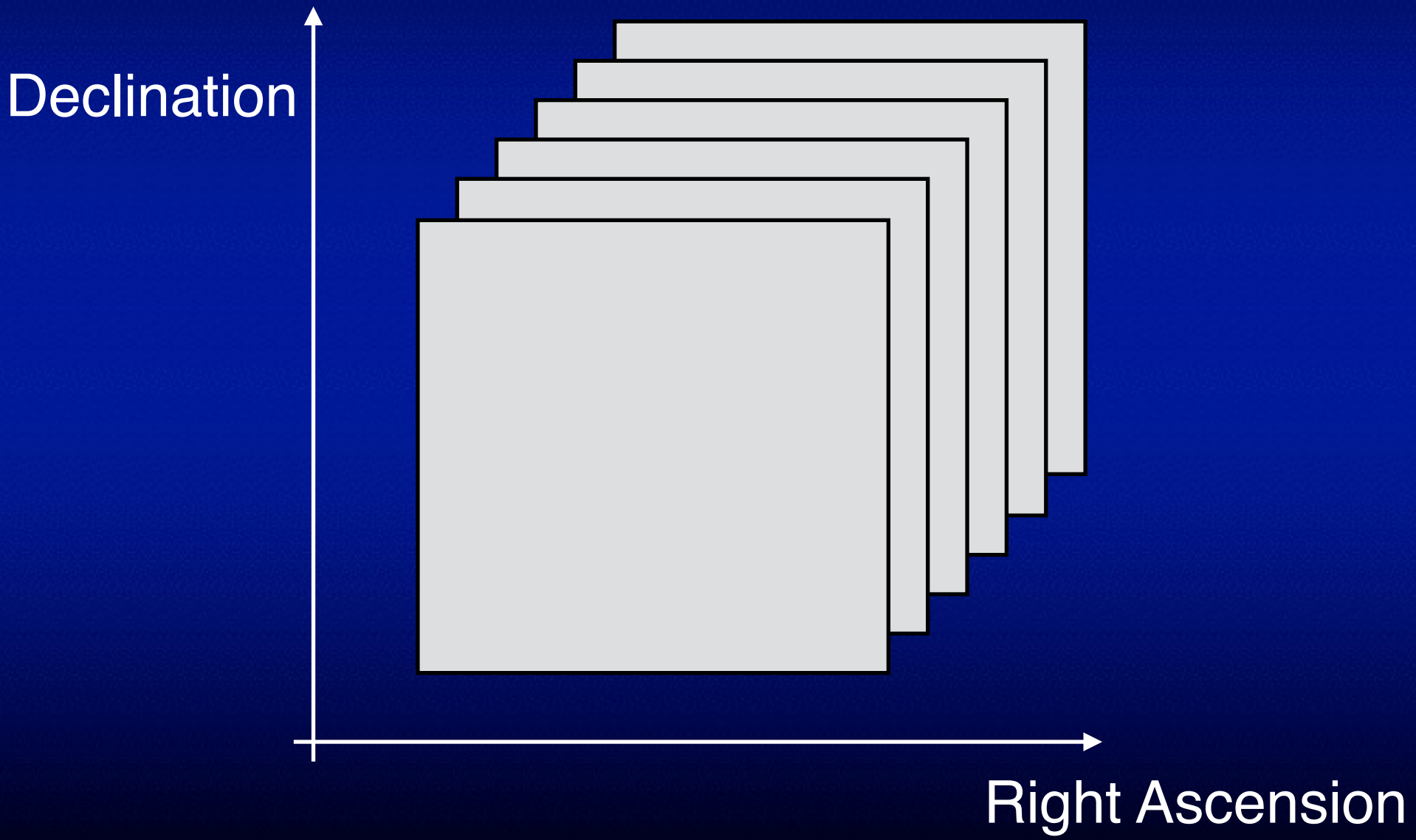
Data Cube

$$T(x, y, \nu), \text{ or } T(\alpha, \delta, v_{\rm los})$$

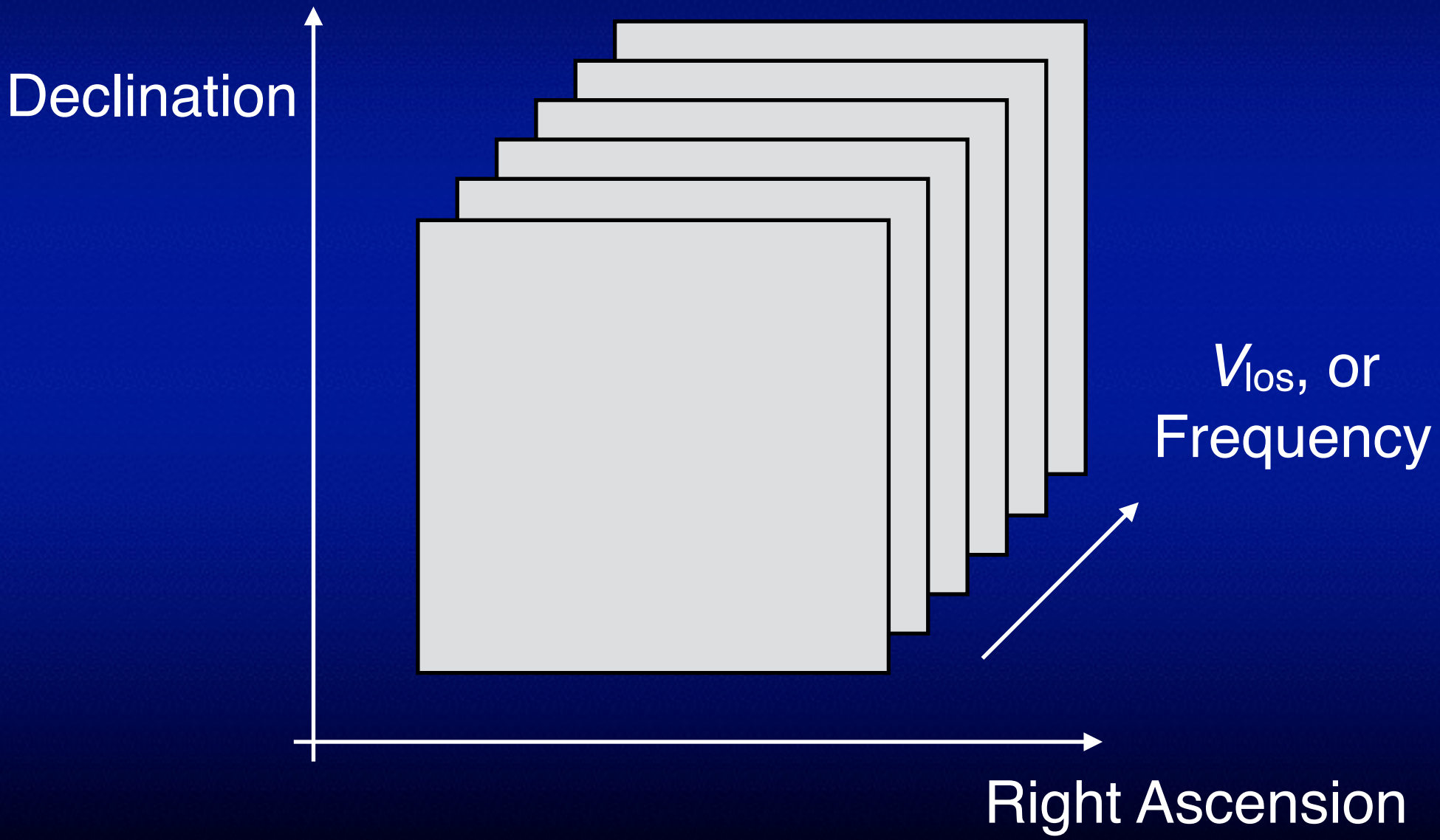
$v_{\rm los}$ is measured in "Local Standard of Rest" (LSR).



Channel Maps



PV Diagram



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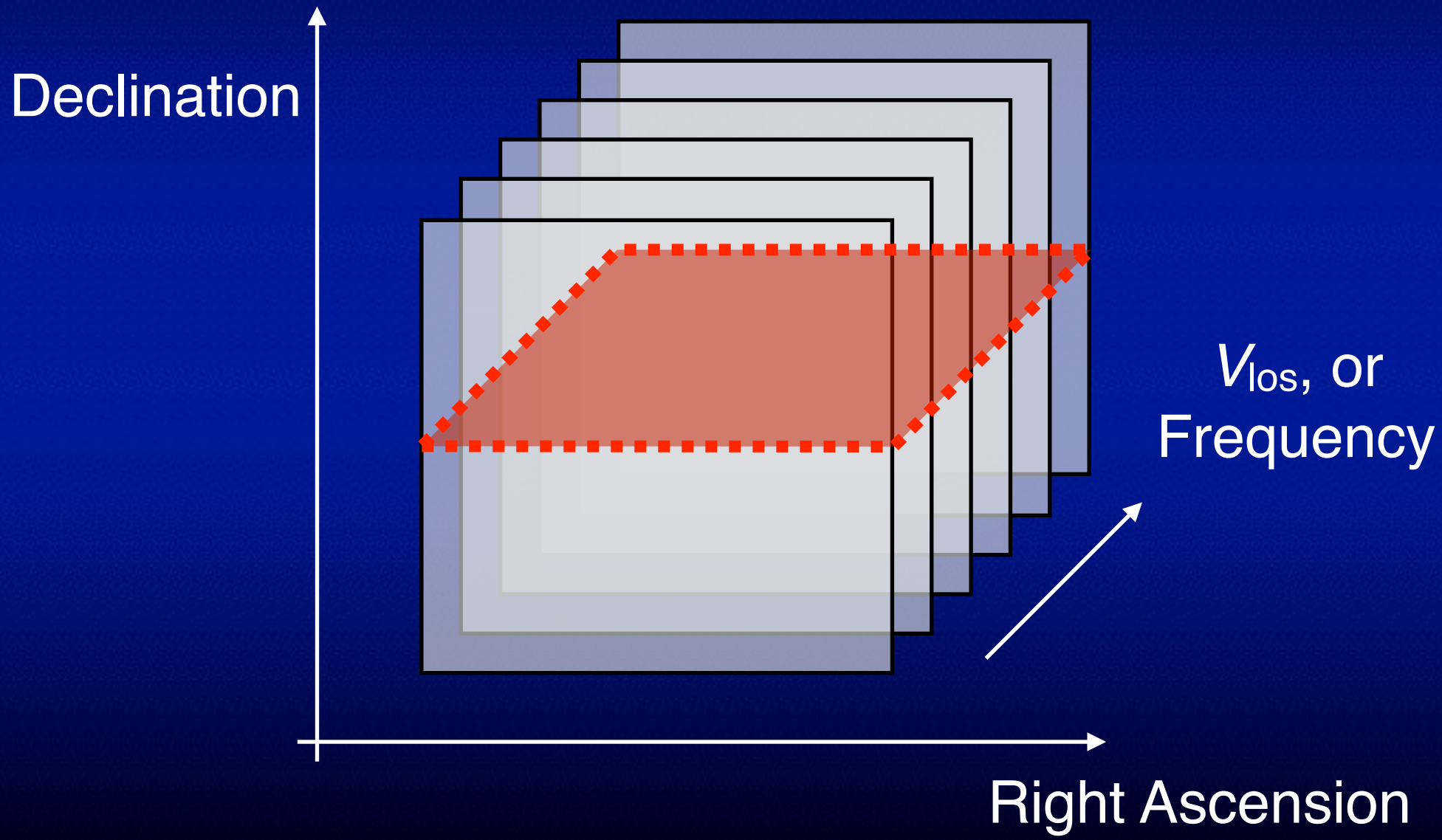

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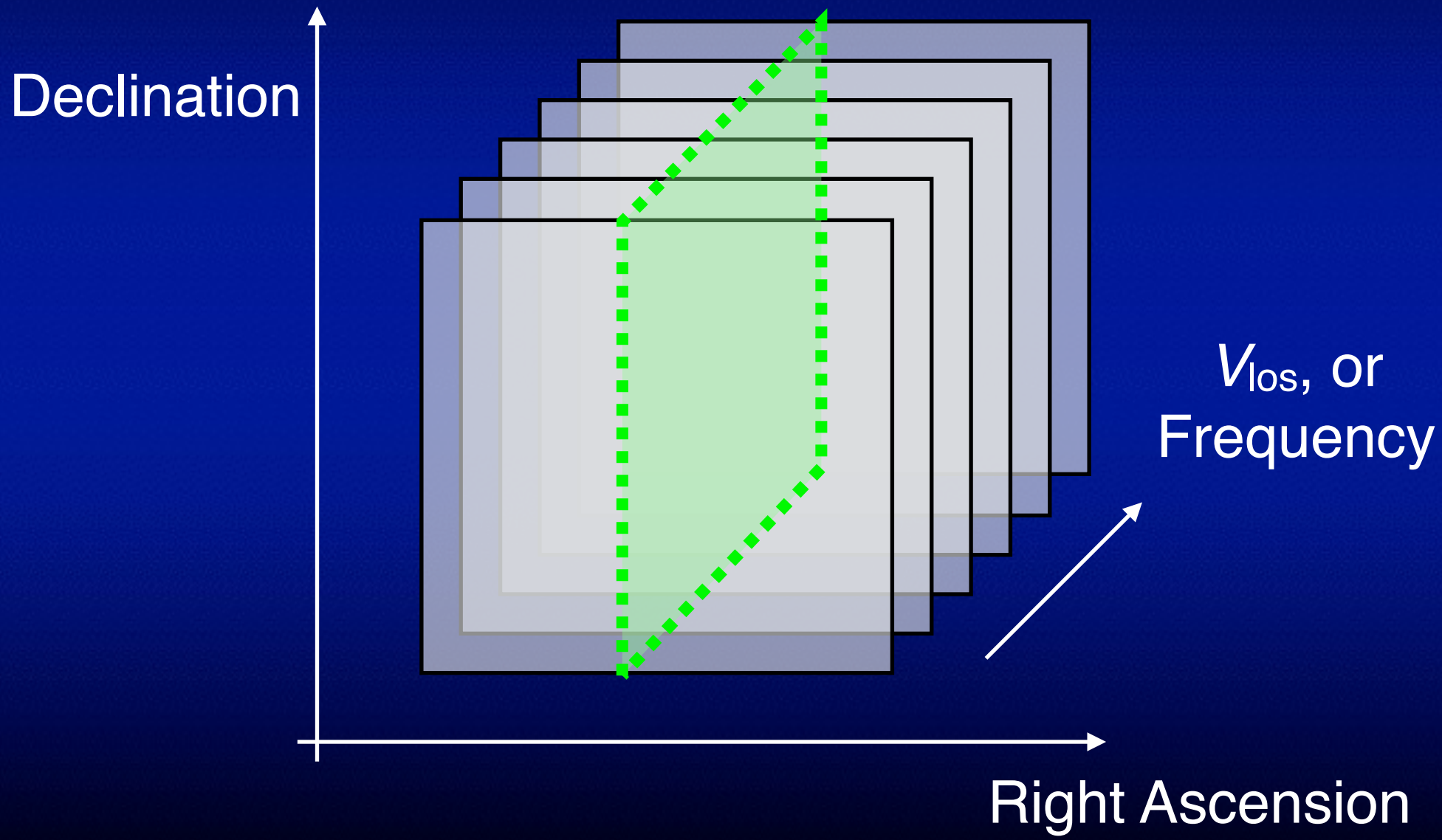

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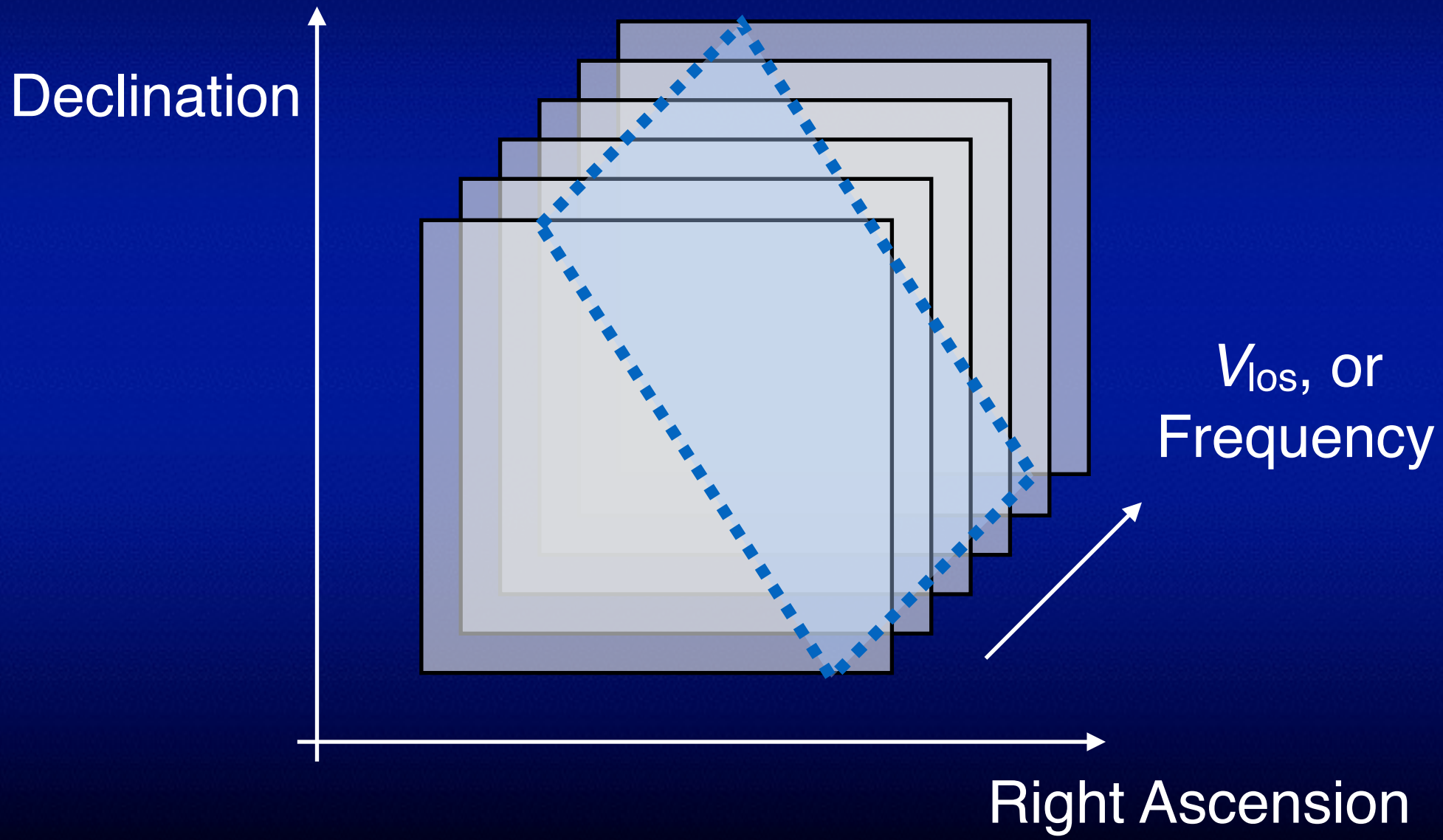


Moment Maps

※以下はすべて場所(α, δ)ごとで計算

$$0\text{th: } I \equiv \int T(v)dv$$

積分強度

$$1\text{st: } \overline{v}_{\rm los} \equiv \frac{\int v \cdot T(v)dv}{I}$$

平均速度

$$2\text{nd: } \Delta v \equiv \sqrt{\frac{\int (v-\overline{v}_{\rm los})^2 \cdot T(v)dv}{I}}$$

$$= \sqrt{\frac{\int v^2 \cdot T(v)dv}{I}} - \overline{v}_{\rm los}.$$

速度分散

局所的なもの

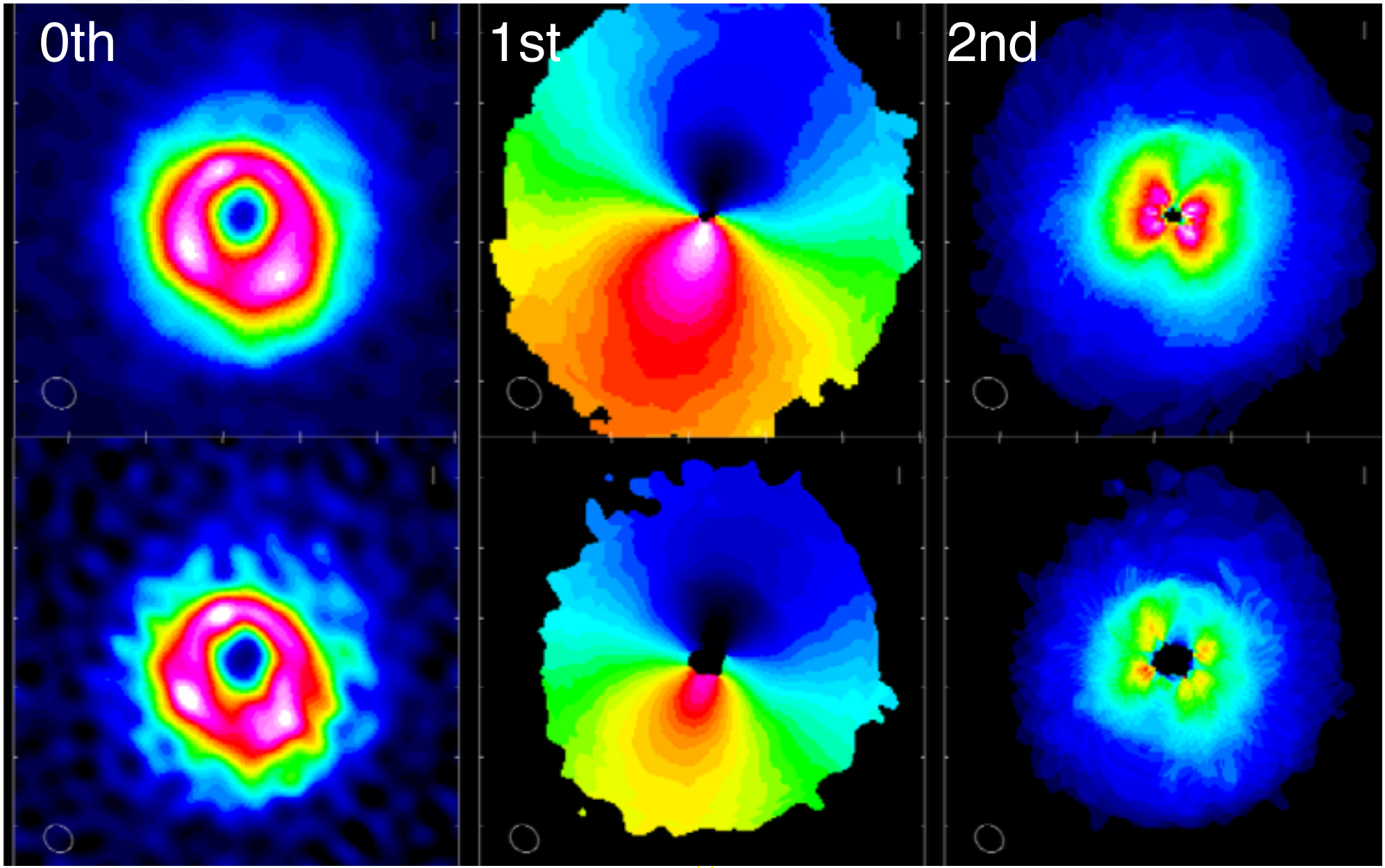
(乱流・熱速度)

+

ビーム内速度勾配

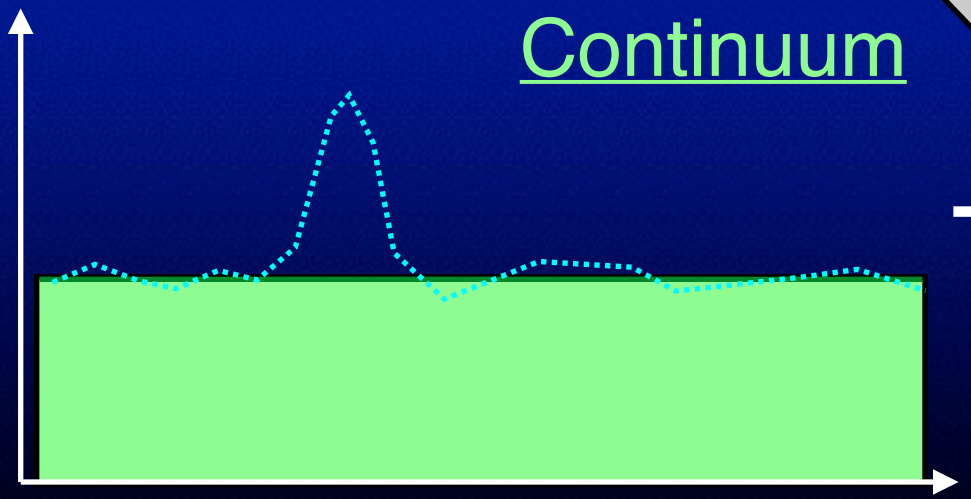
Examples: HD142527 in ^{13}CO (J=3-2)

Briggs Wt (upper) and Uniform Wt (lower)

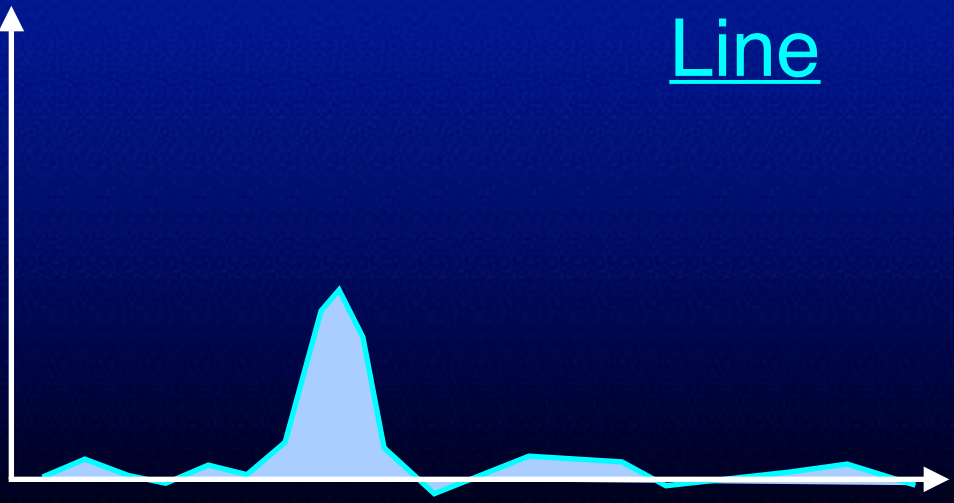


Continuum Subtraction

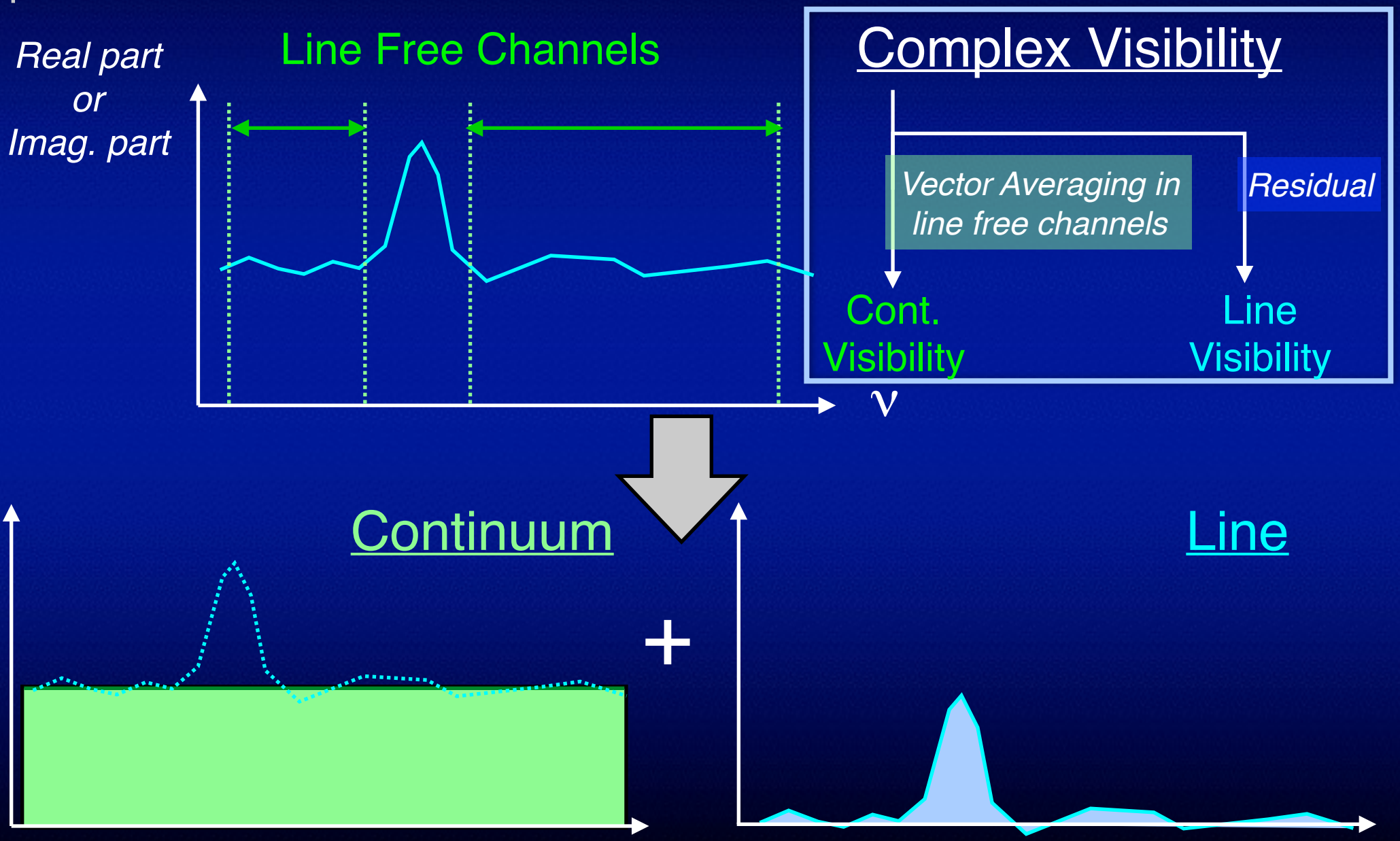
Simple Spectroscopy



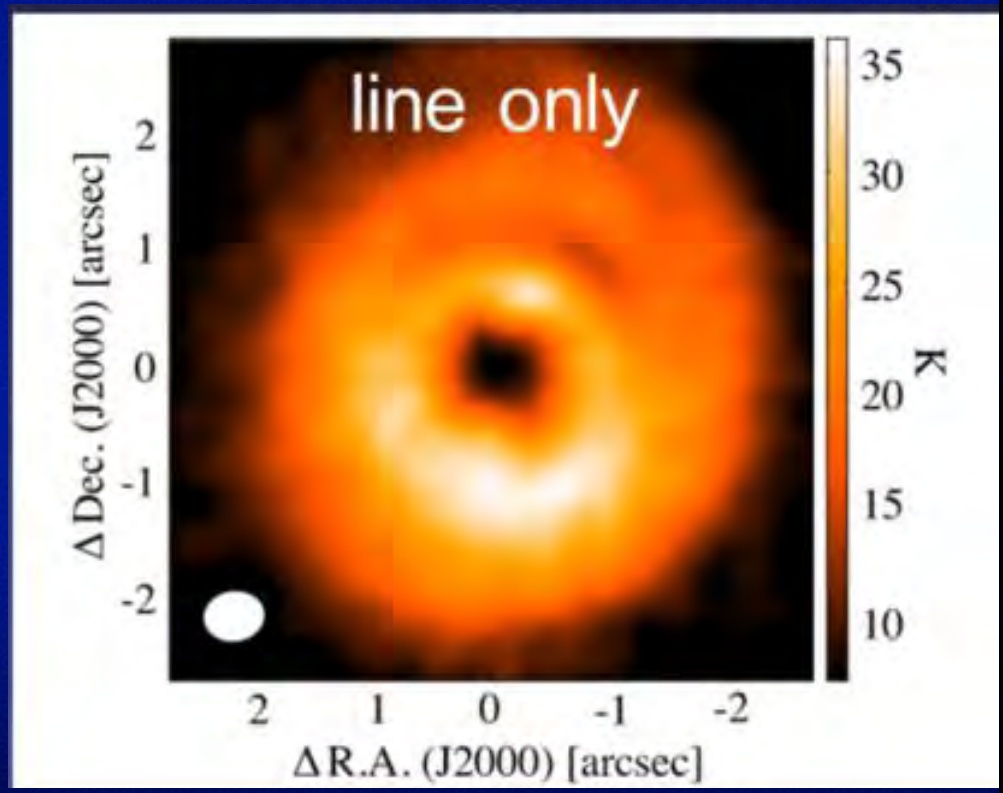
+



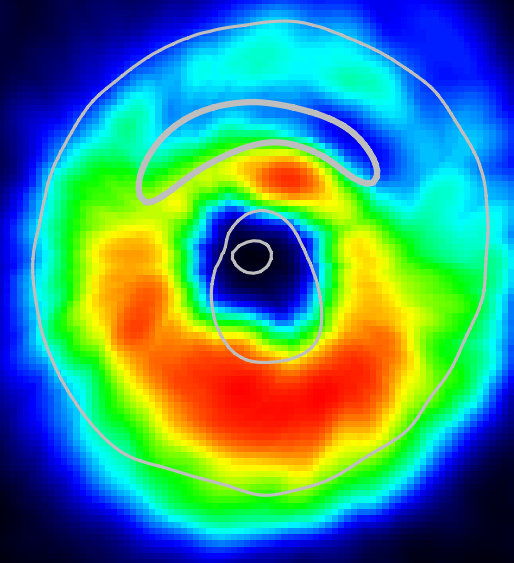
Continuum Subtraction



Peak T_b map of ^{13}CO (J=3-2) around HD142527: Line only and Cont. added



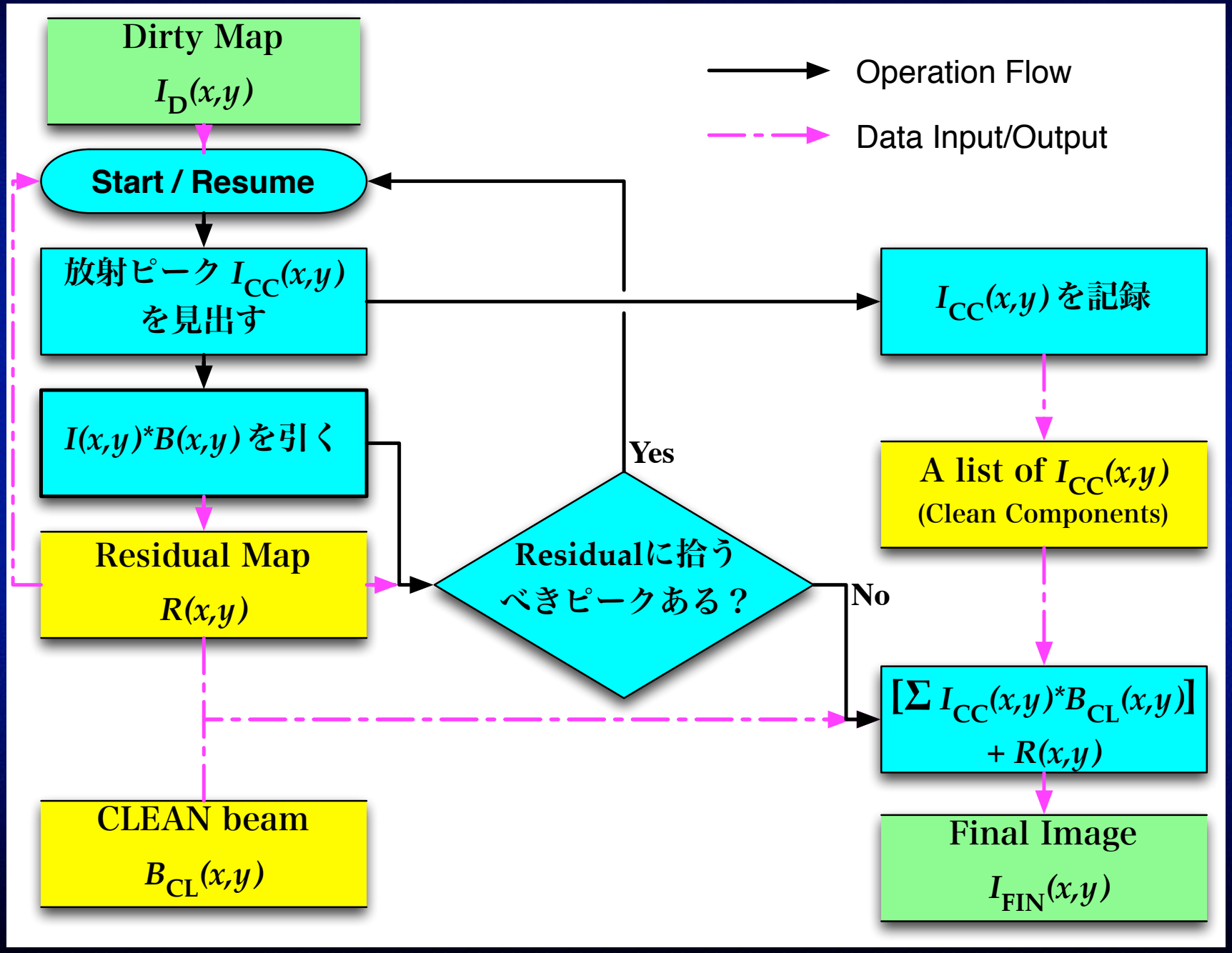
… in different color code



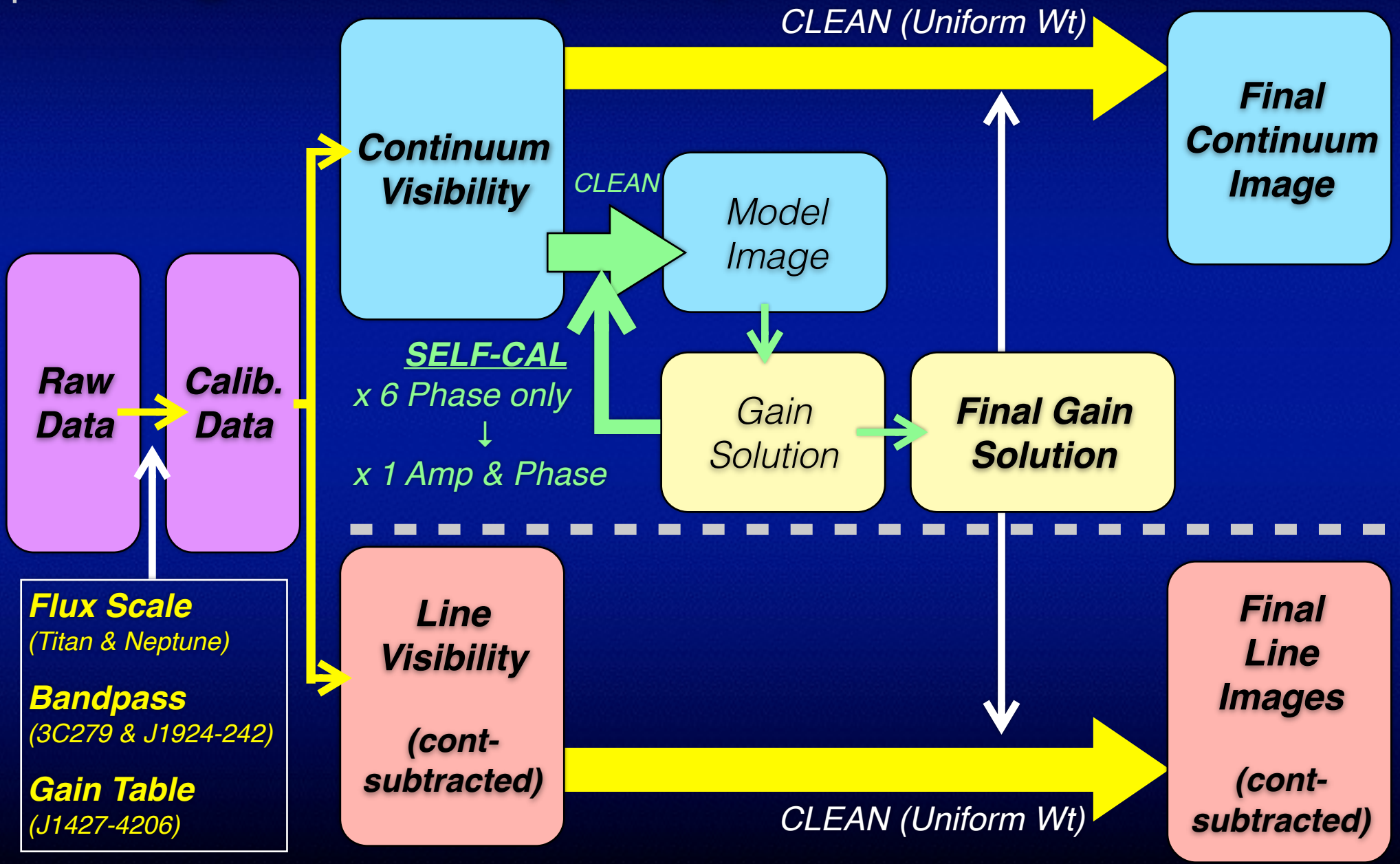
Continuum in grey lines

Advanced Materials

CLEAN Algorithm



Data Reduction in the case of Fukagawa et al. (2013)

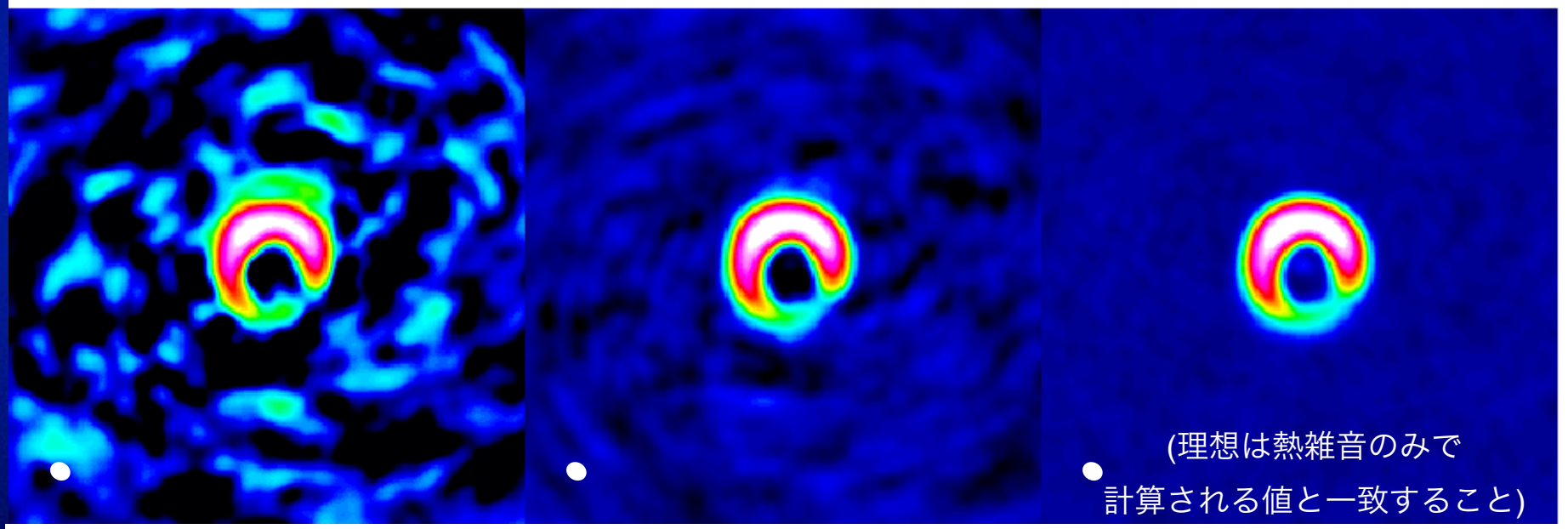


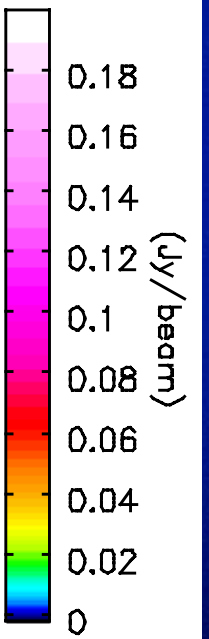
Self-Calibration: “Before-After” HD142527 Continuum @ 330 GHz

Before Self-Cal.

after
1 iteration
solving phase only

Final Image
6 iterations
solving phase +
1 iteration
solving amp. & phase





rms = 2.24 mJy/beam　0.68 mJy/beam　0.13 mJy/beam

※少しずつ慎重に（やり過ぎると1箇所に放射を集める場合あり）

※独立した偏波成分を取得する受信機同士でconsistentな解を示しているか

Self-Calibration

明るくコンパクト

瞬時瞬時のVisibility Phaseを支配。予測可能。

$N_{ant} < N_{baseline}$

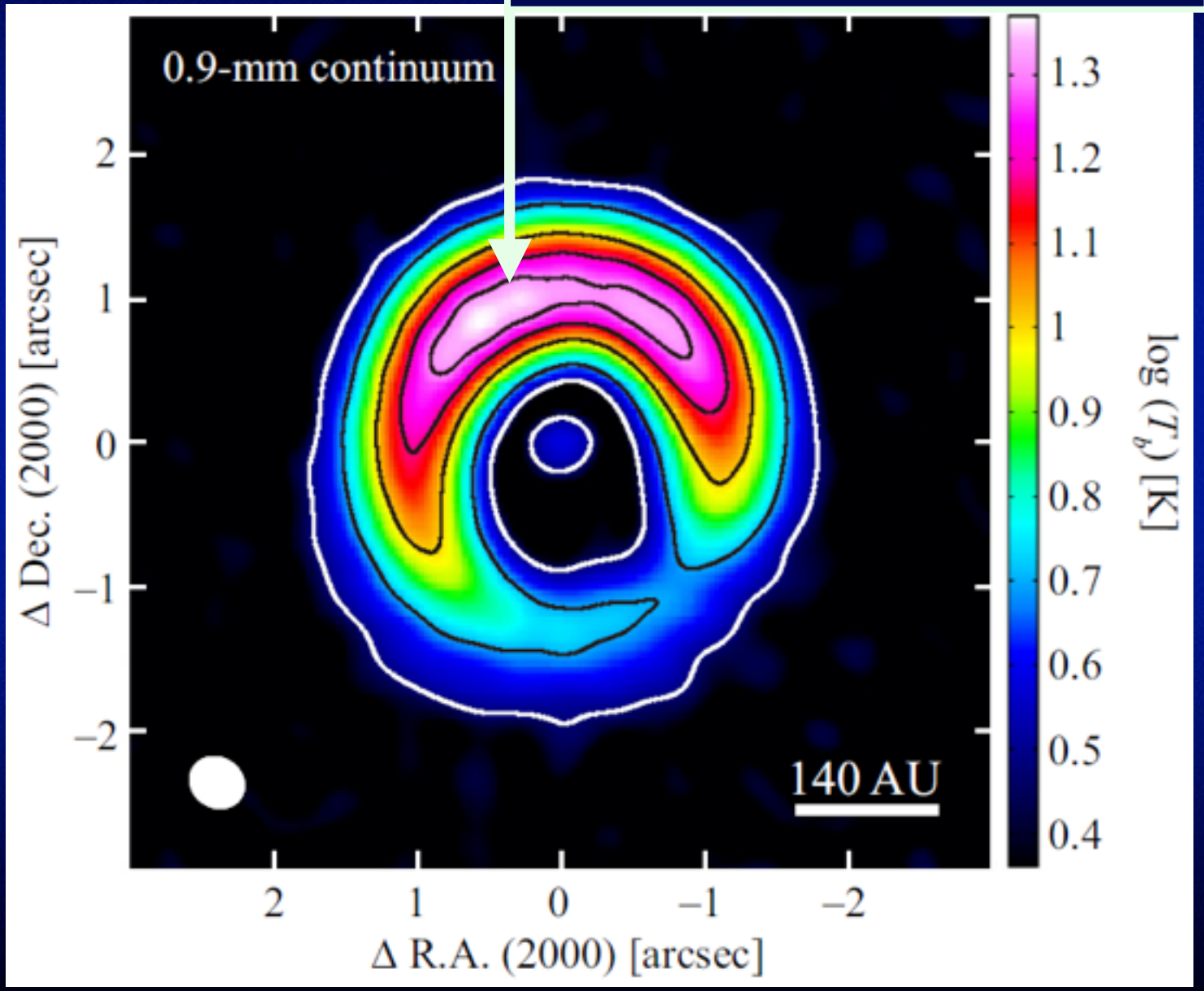
↓

アンテナベースの位相誤差

(大気水蒸気の揺らぎ,
装置の位相揺らぎ等)

を解くことができる

(モデルイメージの解との比較)



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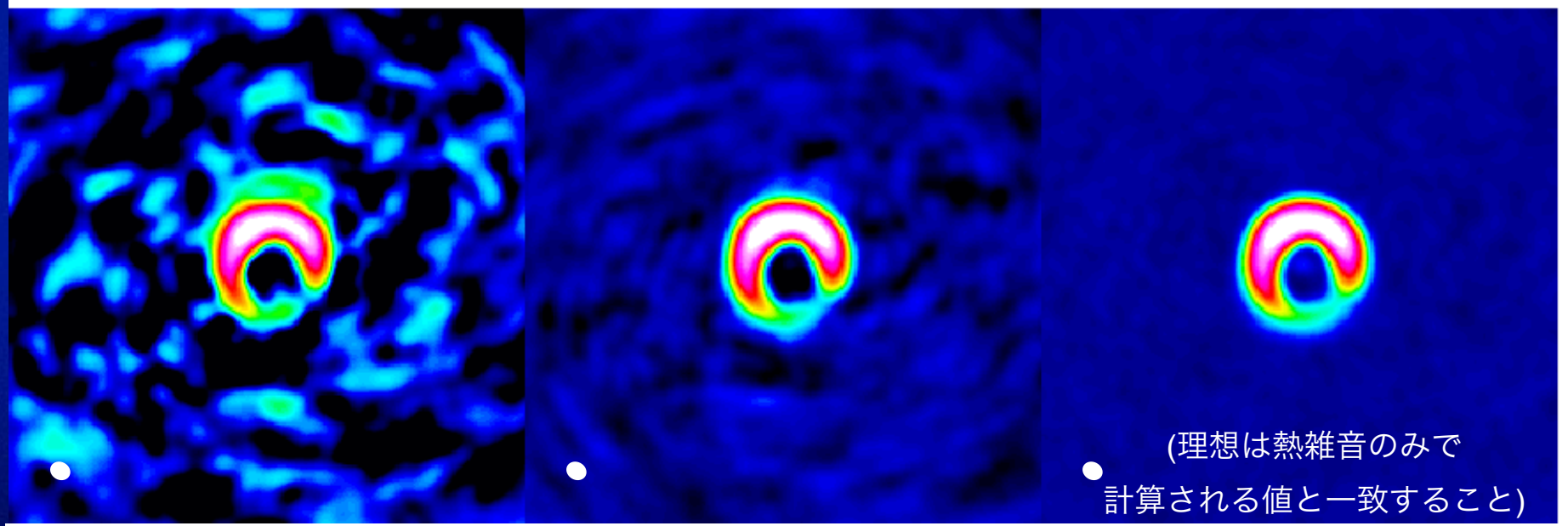

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